REMARKS

Upon entry of this amendment, claims 1 and 4-9 are all the claims pending in the application. Claims 2 and 3 have been canceled by this amendment.

Applicants note that a number of editorial amendments have been made to the specification and abstract for grammatical and general readability purposes. Due to the number of changes made, a substitute specification and abstract are submitted herewith. No new matter has been added. Also enclosed is a marked-up copy of the original specification and abstract showing the changes incorporated into the substitute specification and abstract.

I. Claim Rejections under 35 U.S.C. § 102

The Examiner has rejected claims 1-9 under 35 U.S.C. § 102(e) as being anticipated by Tokumoto (U.S. 6,998,421).

By this amendment, claims 2 and 3 have been canceled and the features recited therein have been incorporated into claim 1. Accordingly, claim 1 now recites that a first detecting section includes a first magnet and a first detecting element of magnetism confronting the first magnet, and that a second detecting section includes a second magnet and a second detecting element of magnetism confronting the second magnet. Applicants respectfully submit that Tokumoto does not disclose or suggest such features.

Regarding Tokumoto, Applicants note that this reference discloses a detecting device which includes an input shaft 32 having a first target gear 34 connected thereto, a torsion bar 31, and an output shaft 33 having a second target gear 35 and a third target gear 36 connected thereto (see Figs. 1 and 2).

As explained in Tokumoto, first magnetic sensors A1 and B1 are arranged outside of the outer circumference of the first target gear 34, and are used to output a signal according to the rotation angle of the input shaft 32 (see Figs. 1 and 2; and col. 4, lines 8-18). Similarly, second magnetic sensors A2 and B2 are arranged outside of the outer circumference of the second target gear 35, and are used to output a signal according to the rotation angle of the output shaft 33 (see Figs. 1 and 2; and col. 4, lines 8-14 and 18-21). Further, third magnetic sensors A3 and B3 are arranged outside of the outer circumference of the third target gear 35, and are used to output a signal according to the rotation angle of the output shaft 33 (see Figs. 1 and 2; and col. 4, lines 8-14 and 20-23).

Regarding the magnetic sensors A1-A3 and B1-B3, Tokumoto describes that the sensors A1, B1 confront the teeth of the first target gear 34, that the sensors A2, B2 confront the teeth of the second target gear 35, and that the sensors A3, B3 confront the teeth of the third target gear 36 (see col. 4, lines 34-38 and Fig. 2). In addition, Tokumoto describes that the magnetic sensors A1-A3 and B1-B3 include magnetoresistive effect (MR) elements a1-a3 and b1-b3, respectively (see Fig. 4A and col. 4, lines 51-55).

In the Office Action, the Examiner has taken the position that the sensors A1, B1 of Tokumoto correspond to the "first detecting section" as claimed, and that the sensors A2, B2, A3, B3 of Tokumoto correspond to the "second detecting section" as claimed (see Office Action at page 2). Applicants respectfully disagree.

In particular, as noted above, claim 1 recites that the first detecting section includes a first <u>magnet</u> and a first <u>detecting element</u> of magnetism <u>confronting</u> the first <u>magnet</u>, and that

a second detecting section includes a second magnet and a second detecting element of magnetism confronting the second magnet.

For example, as described in an illustrative non-limiting embodiment of the present invention, first magnet 8 confronts first detecting element of magnetism 10, and second magnet 9 confronts second detecting element of magnetism 11 (see Fig. 1 of the present application).

In contrast to the configuration described above in claim 1, Tokumoto merely describes a plurality of magnetic sensors A1-A3 and B1-B3, wherein the sensors A1 and B1 confront the first target gear 34, the sensors A2 and B2 confront the second target gear 35, and the sensors A3 and B3 confront the third target gear 36 (see Figs. 1 and 2).

Thus, taking sensors A1 and B1 of Tokumoto as an example, which the Examiner indicated corresponds to the "first detecting section" as recited in the claimed invention, Applicants note that while sensors A1 and B1 include magnetoresistive elements a1 and b1, and confront the first target gear 34, it is respectfully submitted that the sensors A1 and B1 do not include a first magnet and a first detecting element of magnetism confronting the first magnet, as recited in amended claim 1.

Similarly, Applicants note that while sensors A2, B2 and A3, B3 are arranged to confront gears 34 and 35, respectively, that the sensors A2, B2 and A3, B3 do not include a second magnet and a second detecting element of magnetism confronting the second magnet, as recited in amended claim 1.

In view of the foregoing, Applicants respectfully submit that Tokumoto does not disclose, suggest or otherwise render obvious at least the above-noted features recited in claim 1. Accordingly, Applicants submit that claim 1 is patentable over Tokumoto, an indication of which is kindly requested.

Further, Applicants note that the Examiner has taken the position in the Office Action that first target gear 34 of Tokumoto corresponds to the "first gear" as recited in claim 1, and that the second and third targets gears 35 and 36 of Tokumoto correspond to the "second gear" as recited in claim 1. Applicants note, however, that the Examiner has not identified which gears of Tokumoto allegedly correspond to "gear A" and "gear B" as recited in claim 1.

In this regard, it is noted that claim 1 indicates that the "gear A" engages with the "first gear" and that the "gear B" engages with the "second gear". Applicants respectfully submit that Tokumoto does not disclose or in any way suggest the combination of a "first gear", a "second gear", a "gear A", and a "gear B" as specifically recited in claim 1.

In view of the foregoing, Applicants respectfully submit that Tokumoto does not disclose or suggest all of the features recited in claim 1. Accordingly, Applicants submit that claim 1 is patentable over Tokumoto, an indication of which is kindly requested.

Regarding claims 4-9, Applicants note that these claims depend from claim 1 and are therefore considered patentable at least by virtue of their dependency.

II. Conclusion

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited.

If any points remain in issue which the Examiner feels may best be resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

Respectfully submitted,

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DESCRIPTION

Version with Markings to Show Changes Made

Detector of Absolute Rotation Angle and Torque

Technical Field

The present invention relates to a detector, mounted to a torsion bar, for detecting an absolute rotation angle and torque simultaneously. The detector of the present invention is used in a power steering of cars.

Background Art

Fig. 6 shows a conventional detector of a rotation angle and torque. Gear 18 is mounted to an input shaft (not shown) of a torsion bar. Gear 21 engaging with gear 18 includes round-shaped code plate 20 having numbers of magnetic poles. Code plate 20 rotates following the rotation of the input shaft. Detecting element 22 of magnetism counts the number of poles rotating, thereby detecting a rotation angle of the input shaft. Gear 42 is mounted to an output shaft (not shown) of the torsion bar, and detects a rotation angle of the output shaft in the same manner as discussed above. When torque works to the torsion bar, thereby producing torsion on the shaft, a comparison of rotation angles between the input shaft and the output shaft will detect the torque.

However, a more accurate rotation angle requires code plate 20 to have greater numbers of poles, so that the dimensions of the detector will become greater. Placement of detecting elements 22 in a radius direction on code plate 20 will also enlarge the detector. The conventional detector discussed above cannot detect an absolute rotation angle.

Summary ~~Disclosure~~ of the Invention

A detector of the present invention comprises the following elements:

a torsion-bar unit including an input shaft, an output shaft, and a torsion bar;

a first gear coupled to the input shaft;

gear A engaging with the first gear;

a first detecting section, placed at the center of gear A, for detecting an absolute rotation angle;

a second gear coupled to the output shaft;

gear B engaging with the second gear; and

a second detecting section, placed at the center of gear B, for detecting an absolute angle.

Brief Description of the Drawings

Fig. 1 shows a structure of a detector of an absolute rotation angle and torque in accordance with an exemplary embodiment of the present invention.

Fig. 2 shows schematically how to find an absolute rotation angle.

Fig. 3 shows schematically how to find a torsion angle.

Fig. 4 shows a block diagram of a detector in accordance with an exemplary embodiment of the present invention.

Fig. 5 shows schematically how to correct an error.

Fig. 6 shows a conventional detector of a rotation angle and torque.

Detailed Description of ~~Preferred Embodiments~~ the Invention

An exemplary embodiment of the present invention is demonstrated hereinafter with reference to the accompanying drawings.

Fig. 1 shows a structure of a detector of an absolute rotation angle and

torque in accordance with an exemplary embodiment of the present invention. A torsion-bar unit is formed of input shaft 2, torsion bar 5 and output shaft 4, wherein these ~~and those~~ elements are made of the same rigid body and placed concentrically. First gear 1 and second gear 3 are coupled to input shaft 2 and output shaft 4 respectively. First gear 1 engages with gear A6, and second gear 3 engages with gear B7. Gear A6 has first magnet 8 at its center, and gear B7 has second magnet 9 at its center. First magnet 8 and second magnet 9 are magnetized in one pole pair. Board 12 has first detecting element 10 of magnetism confronting first magnet 8, and board 13 has second detecting element 11 of magnetism confronting second magnet 9. First magnet 8 and first detecting element 10 form a first detecting section of an absolute rotation angle. Second magnet 9 and second detecting element 11 form a second detecting section of an absolute rotation angle. First gear 1 and second gear 3 have the same number of teeth "c", gear A6 has the number of teeth "a", and gear B7 has the number of teeth "b" ($a \neq b$).

Next, an absolute rotation angle of first gear 1 and second gear 3 as well as torque applied to torsion bar 5 are described.

In Fig. 1, rotation of input shaft 2 of the torsion-bar unit ~~entails~~ causes first gear 1 and gear A6 to rotate. First detecting element 10 detects a magnetic field of first magnet 8, thereby calculating an absolute rotation angle of gear A6. Rotation of output shaft 4 causes ~~entails~~ second gear 3 and gear B7 to rotate. Second detecting element 11 detects a magnetic field of second magnet 9, thereby calculating an absolute rotation angle of gear B7.

Fig. 2 depicts a method of calculating an absolute rotation angle. The lateral axis represents absolute rotation angle "z" of first gear 1 and second gear 3. The upper column shows absolute rotation angles "x" and "y" of gear A6 and gear B7 respectively. The lower column shows a difference "x – y" between the

absolute rotation angles of gear A6 and gear B7. As shown in Fig. 2, the difference "x – y" forms ~~draws~~ a straight line and is uniquely related to absolute rotation angle "z", which can be thus calculated from the difference "x – y".

The ordinate axis of Fig. 3 shows difference T which is found from the following equation: $T = x - y\ b/a$

When torsion bar 5 does not have torsion, difference T changes step by step as shown in Fig. 3. If torsion bar 5 produces torsion ΔT, difference T changes by $\Delta T * (c/a)$ with respect to the case where no torsion is produced, so that torsion angle ΔT can be calculated. This $\Delta T * (c/a)$ is added to (x – y) shown in Fig. 2, so that a detection accuracy of absolute rotation angle "z" can be improved. Torque can be calculated using torsion angle ΔT. When torsion angle ΔT exceeds a given allowance, the detector determines that an abnormality occurs and gives a warning.

An absolute rotation angle and torque can be also detected in the condition of gear A6 and gear B7 having the same number of teeth, and first gear 1 having a different ~~has the~~ number of teeth ~~different~~ from that of second gear 3.

As shown in Fig. 4, first detecting element 10 and second detecting element 11 are coupled to CPU 14, to which non-volatile memory EEPROM 15 is also coupled. On the other hand, CPU 14 is coupled to master CPU 17 via serial communication line 16 in order to output an absolute rotation angle and torque calculated by CPU 14.

It is desirable to mount gear A6 and gear B7 with respective positions of zero-rotation angle of both the gears being agreed with each other; however, it requires such ~~so~~ elaborate work that the following correction of zero-rotation angle takes the place of the work: Gear A6 and gear B7 are mounted to the torsion-bar unit, then an initial absolute rotation angle of gear A6 is calculated

using a signal supplied from first detecting element 10, and that of gear B7 is calculated using a signal supplied from second detecting element 11. Those angles calculated are stored in EEPROM 15, and every time the power is turned on, the angles are read from EEPROM 15. A rotation angle starting from each one those initial absolute rotation angles is defined as respective absolute rotation angles of gear A6 and gear B7.

Further, as shown in Fig. 5, absolute rotation angles (shown in solid lines) calculated by the detecting elements include errors due to a variety of factors with respect to respective correct absolute rotation angles (shown in broken lines), so that the following correction is provided: Gear A6 and gear B7 are mounted to the torsion-bar unit, then input shaft 2 is rotated with high accuracy, thereby obtaining a correction angle that is a difference between the correct absolute rotation angles and the absolute rotation angles of gear A6 and gear B7 calculated by the detecting elements. This correction angle is stored in EEPROM 15, and every time the power is turned on, this correction angle is read and added to the angles calculated by the detecting elements, so that an absolute rotation angle approximate ~~approximating~~ to the correct one is obtainable.

Industrial Applicability

The detector of an absolute rotation angle and torque is suited to a power steering of cars.

ABSTRACT

A detector of an absolute rotation angle and torque ~~is disclosed. The detector~~ includes a first gear ~~(1)~~ coupled to an input shaft ~~(2)~~ of a torsion-bar unit, a gear A ~~(6)~~ engaging with the first gear ~~(1)~~, and a first detecting section of an absolute rotation angle placed at the center of the gear A ~~(6)~~. The detector also includes a second gear ~~(3)~~ coupled to an output shaft ~~(4)~~ of the torsion-bar unit, a gear B ~~(7)~~ engaging with the second gear ~~(3)~~, and a second detecting section of an absolute angle placed at the center of gear B ~~(7)~~.